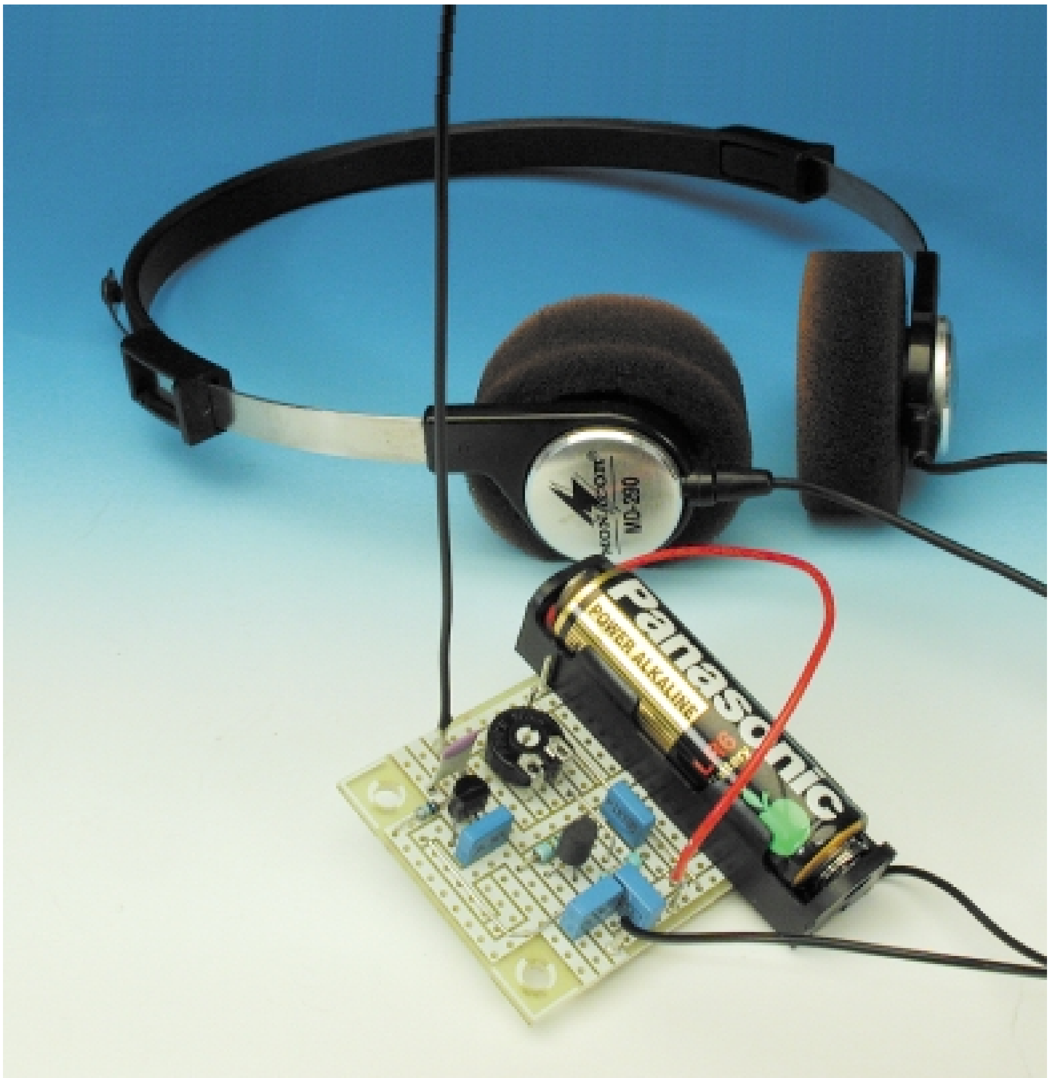
1.5-Volts Medium Wave (MW) Radio

and now for something smaller.

From an idea by W. Zeiller

In this day and age when we're surrounded by hi-tech we should leave it all behind and return to a very basic circuit. So stop thinking for a moment about faster and bigger — it's the small things in life which are best!



Since we're continuously exposed to hi-tech gadgets, it's easy to forget that we can still build interesting circuits with only a few components. There is nothing revolutionary about this circuit, but this shouldn't deter the true electronics hobbyist. Apart from the educational aspect, it is satisfying to build a well-working circuit that uses only a few simple components.

The circuit for a radio receiver is still a good example of this. A medium wave radio in particular becomes a very simple circuit when we go back to basics. It is also one of the most satisfying circuits to construct: you solder a few components onto a PCB, connect a battery and you're greeted with music from the headphones. A very memorable experience!

Direct Conversion

What would be the simplest and most compact design for a medium wave radio? A superheterodyne receiver, as was used in the 'AM Receiver' in the February 2001 issue, is not suitable since it makes the circuit too complex. Rather, we should think about direct conversion techniques, as found in the good old crystal receiver.

The principle of operation of a direct conversion receiver is that the received signal (after selection and amplification) is demodulated directly, without the use of IF oscillators and the mixing of signals. In a nutshell, a direct conversion receiver is the purest type of radio, giving a superior sound quality; the total absence of whistles and squeaks is also a contributory factor.

In its simplest form, a direct conversion AM receiver consists of an RF input circuit, a diode detector and high-impedance headphones. Such a miniature radio can easily fit inside a matchbox and has the added advantage that it doesn't need a power supply. A shortcoming of such a receiver is that its sensitivity is a bit low, because no amplification takes place. You'll need a good aerial and ground connection for worthwhile reception to occur.

A big improvement in its performance can be obtained by amplifying the received RF signal before it is fed to the detector stage. This increases the sensitivity to a level where reasonable reception is still obtained when using a whip or ferrite rod aerial. The selectivity of the receiver can be improved by designing the RF amplifier with a high-impedance input, reducing the load on the RF input stage.

Clever chip

The design of the above circuit is enormously simplified by the availability of a very useful and inexpensive IC. This is the small MK484, which has a TO92 case like a BC547. In the past Ferranti made this chip, with a part number of ZN414. In fact, this integrated marvel contains a complete AM receiver, requiring only a tuned circuit and an optional audio amplifier to make a complete radio.

Figure 1 represents the internal block diagram of the MK484. As can be seen, this IC contains a high-impedance input stage (shown here as an emitter follower), a (three-stage) RF amplifier, an AM detector and an Automatic Gain Control circuit (AGC), which adapts the amplification according to the level of the input signal. The input stage has an input impedance of 4 MΩ, which makes it possible to connect the MK484 directly to the tuned circuit without having to worry that it causes too much loading. The coil of the tuned circuit therefore doesn't need a tap, which simplifies the construction.

What isn't shown in **Figure 1**, but what is a very useful property of the MK484, is that it, like its illustrious predecessor, has been designed to work from a supply of 1.5 V (1.1 to 1.8 V), with a current consumption of only 0.3 mA. This makes it possible to power the receiver from a single penlight (AA) battery; even a button cell has enough capacity to power the MK484 for several hundred hours!

Using a minimum of components

The circuit diagram in **Figure 2** is of a typical receiver with an MK484 at its hart. It can be seen that only a few external components are required: a tuned circuit (L1/C1), a bias resistor (R1) and a load resistor (R2), which also sets the operation of the AGC. If you can get hold of a high-impedance (200 to 1000 Ω) magnetic earphone you could mount this in place of R2, which makes the amplifier built round T1 superfluous — the number of components required is then really at an absolute minimum. But since these magnetic earphones are hard to come by, T1 is used to drive a pair of headphones with an impedance of 32 Ω. The number of components used remains fairly small, even with this extra stage.

For reception of stations broadcasting in the medium wave band, the variable capacitor (C1) needs to have a value of 200 pF and inductor L1 should be 470 µH. The coil is made by winding 80 turns of 0.2 mm enamelled copper wire (ECW) onto a 5 cm long ferrite rod, which should have a diameter of about 10 mm.

When using 32 Ω headphones we'd recommend that the two speakers are connected

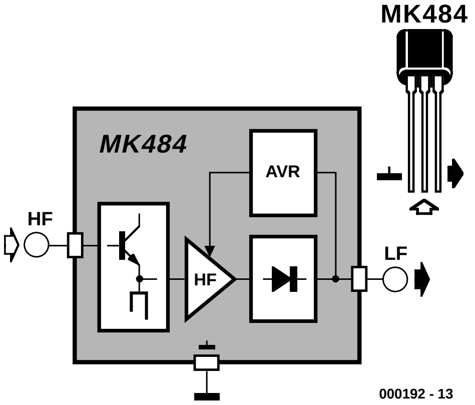


Figure 1. The MK484 contains nearly all the parts required to make a simple AM receiver.

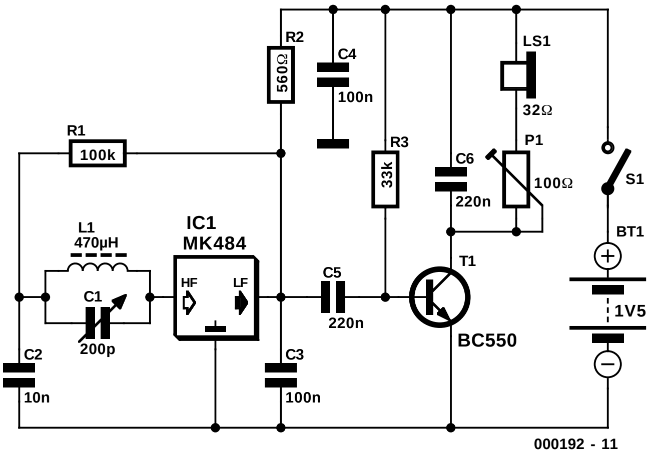


Figure 2. Only a small number of external components is needed. T1 is the headphone amplifier.

in series. This increases the impedance to 64 Ω, which halves the current drain of the audio amplifier built round T1. There is no need to worry that the sound becomes too quiet; you're likely to reduce the volume further with P1.

Coil-less

A competent hobbyist would surely be able to construct the circuit of **Figure 2** such that it fits inside a matchbox, using a button cell for the supply. This is something we've managed to do in the past with a similar design.

Under certain conditions the circuit can be reduced even further. If there is only one strong local medium wave transmitter it becomes possible to leave out the tuned circuit all together. Due to the high gain of the MK484, such a station can be received clearly even without the tuned circuit. The narrow bandwidth of the IC (150 to 3000 kHz) suppresses most interference which could be caused by local shortwave transmitters, if there are any.

This leads us to the circuit shown in **Figure 3**. Since we've lost our aerial with the removal of the ferrite rod, we have to connect a short whip aerial via C1. Some experimentation with the length of the aerial and the value of C1 will be needed in order to get the best reception.

Stamp

With the removal of the tuned circuit we've got rid of the two largest components. So while the circuit of **Figure 2** fits inside a matchbox, that of **Figure 3** could be reduced to the size of a stamp — more so if a fixed resistor is used in place of P1. It will be a challenge for the resourceful constructor to make this receiver as small as possible.

For those of us who don't like such a level of miniaturisation, we've designed a circuit layout for the coil-less receiver shown in **Figure 3**, using an 'UPBS-1' experimenters' board (UPBS = Universal Prototyping Board Size-1). These universal boards are available via our Readers Services and are ideal for this type of project. The recommended layout is shown in **Figure 4**.

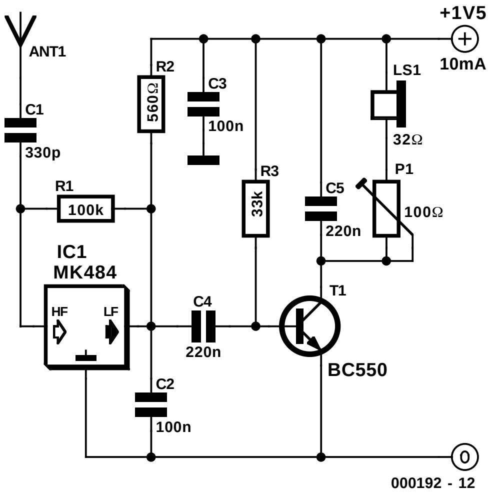


Figure 3. There is not much left without the tuned circuit, but it is still functional.

COMPONENTS LIST

Resistors:
R1 = 100kΩ
R2 = 560Ω
R3 = 33kΩ
P1 = 100Ω preset H

Capacitors:
C1 = 330pF (see text)
C2,C3 = 100nF
C4,C5 = 220nF

Halfgeleiders:
T1 = BC550
IC1 = MK484 (F-501), Conrad Electronics # 178535-88

Miscellaneous:
Headphones 32Ω (or more)
Experimenters' board type UPBS-1 (see Readers Services page)

We'd like to mention that the PCB layout can still be used if you do decide to use an L-C tuned circuit. This should be connected between the junction of C1/R1 and earth, with a DC-blocking capacitor of 10 nF connected in series — in the same way as shown in **Figure 2**.

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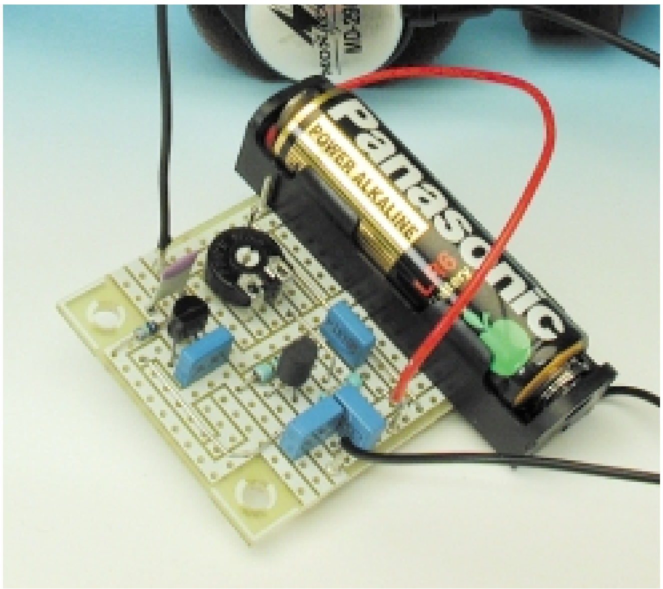

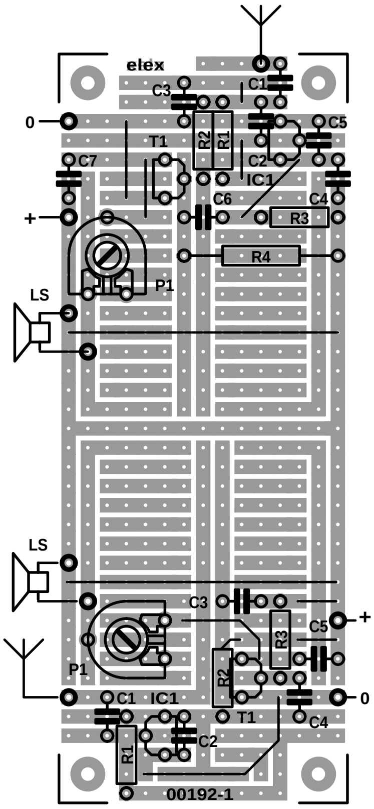

Figure 4. The circuit can be built in a matter of minutes on an UPBS-1 experimenters' board.